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REVIEW

Mondia whitei, a Medicinal Plant from Africa with Aphrodisiac and Antidepressant Properties: A Review

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ABSTRACT. This paper reviews the literature concerning the ethnobotany, phytochemistry, and pharmacology of *Mondia whitei,* which is also known as *Mondia whytei*, African ginger or simply as mondia. Mondia is used in many parts of Africa as a traditional remedy to improve appetite and libido, as a galactagogue, as a fertility medication, and as an antidepressant. In African countries, where it is used medicinally, the most commonly cited use is as an aphrodisiac. The scientific studies reviewed in this report employed either *in vivo* rodent models or isolated organ techniques, and therefore the results cannot be directly extrapolated to humans. Nevertheless, these studies provide scientific evidence that support the traditional uses of mondia as an aphrodisiac and an antidepressant. Based on the safety data available in the literature, mondia is reasonably expected to be safe when prepared and used according to traditional practices.

KEYWORDS. African ginger, antidepressant, antidiarrhea, aphrodisiac, erectile dysfunction, libido, mondia review, *Mondia whitei*, *Mondia whytei*

INTRODUCTION

Mondia whitei (Hook. F.) Skeels Syn. *Chlorocodon whitei* Hook. F., also known as *Mondia whytei*, White's ginger or African ginger (hereafter referred to as mondia) is a plant species indigenous to sub-Saharan Africa (Lamidi & Bourobou, 2010). Mondia is referred to by a variety of names. For example, in the western part of Kenya, it is known as "*ogombo*" or "*mukombelo*" and in Uganda it is referred to as "*mulondo*" whereas in Tanzania it is known as *"mbombongazi"* (Swahili) (Kamatenesi-Mugisha and Oryem-Origa, 2007; Kokwaro, 1976). In Cameroon, mondia is referred to as "*limte*," "*nkang bongo*," "*yang*" or "*la racine*," (Watcho et al., 2007b).

Both the aerial and underground parts of mondia are used as food and medicine; however, the underground part is most commonly used in traditional medicine. Mondia root is traditionally used to treat many conditions. Several of the traditional

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uses include use as an aphrodisiac, a tonic, an appetite stimulant, and a treatment for indigestion (Kokwaro, 1976). Mondia is also reportedly used to treat sexually transmitted diseases, such as gonorrhea, and as a uterine stimulant for women during parturition, as well as a treatment for constipation, bilharziasis, stress, and tension (Watt & Breyer-Brandwijk, 1962).

THE ETHNOBOTANY OF MONDIA WHITEI

Taxonomically, *Mondia whitei* is classified in the family Apocynacea under the subfamily Periplocoideae (Lamidi & Bourobou, 2010; Venter, Verhoeven, & Bruyns, 2009). Mondia is widely distributed in tropical Africa from Senegal in the west to southern Sudan in the east and throughout most of Central Africa and South Africa. Mondia is a vigorously growing woody creeper that reaches 6 m in height with leaves that are heart-shaped and spread out on a petiole that is 3–6 cm long. The leaf blades are 10–18 cm long. The flowers are arranged in a panicle with yellow and reddish-purple petals (Lamidi & Bourobou, 2010).

Verbal and written history indicates that mondia has been used in traditional medicine for many generations in many communities all over Africa (Cunningham, 1997). The most commonly cited use is as an aphrodisiac. In East Africa, the vernacular Luo name for mondia is "*ogombo*," a term that translates to the English word "desire." Among the Luo people, *ogombo* is believed to awaken life's desires, which include the desire for food, sex, and happiness, and this plant is used as an aphrodisiac and an appetite stimulant (Adoyo, 1999; Kokwaro, 1976). Mondia could therefore be considered as an adaptogen, as it appears to have a wide range of uses related to restoring wellbeing. In the western part of Kenya, particularly in Kakamega, mondia is known as *"mukombero"* or *"mkombelo"* and is used to enhance fertility and vitality, as well as to treat stomachache and rheumatism (Olembo, Stephen, & Edah, 1995). The roots of mondia can be used fresh or dried. When used fresh, the roots are pounded and steeped in water overnight. The preparation is subsequently filtered through a clean cotton cloth, or the filtrate is decanted after the solids have settled. The filtrate is drunk as is or is mixed with porridge then drunk. Dry or fresh roots may also be cooked in meat or chicken stews to enhance the stew flavor and to improve preservation. Dried mondia roots are sold in open markets all over Kenya, where both men and women of various ages chew them. The roots taste bitter-sweet at first but become sweet over time. After chewing mondia root, the taste buds are modified such that drinking water tastes sweet or sugary.

In Uganda, mondia is popularly known as "*mulondo.*" Similar to its use across the border in Kenya, the *mulondo* root is employed as an aphrodisiac. Extensive survey of vendors and users in Kampala reported that mulondo is highly valued as an aphrodisiac such that no other substitutes are acceptable in its absence (Agea, Katongole, Waiswa, & Nabanoga, 2008; Kamatenesi-Mugisha & Oryem-Origa, 2007). These studies also found that vendors and buyers included men and women equally. However, women were unwilling to openly admit to using the herb for treatment, even though an earlier study by Kamatenesi-Mugisha reported that both women and men used mondia roots as an aphrodisiac in most parts of Uganda (Kamatenesi-Mugisha & Oryem-Origa, 2007; Kamatenesi-Mugisha &

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Oryem-Origa, 2005). Mondia is also reportedly used for the treatment of diabetes and hypertension, as a flavoring agent, and as a galactagogue (World-Bank, 2005). Other reports indicate that mondia extract is used to treat poultry diseases in East Africa (Okitoi et al., 2007).

In Cameroon in central Africa, an infusion made with mondia root is ingested as an aphrodisiac, an appetizer and as a breath freshener (Noumi, Amvam, & Lontsi, 1998). In Malawi, the mondia root is popularly known as *"gondolosi"* and is used not only as an aphrodisiac but also to treat male impotence and infertility, urinary tract infections, jaundice, and headaches. The entire plant is also used to treat diarrhea (Brian & Msonthi, 1996; Msonthi, 1991; Msonthi, Toyota, Martston, & Hostettmann, 1989; Adjanohoum et al., 1996; Noumi et al., 1998). In Zimbabwe, mondia is used to treat schistosomiasis, constipation, and anorexia in addition to being used as an aphrodisiac (Msonthi *et al.*, 1989; Sparg, van Staden, & Jager, 2000). Mondia seeds are reportedly used as poison on arrows (Burkhill, 1997).

In South Africa, mondia (the root and the whole plant) is used by different ethnic groups to treat a myriad of conditions. The Zulu chew the roots to stimulate appetite and also use it as a flavoring agent in soft drinks and for the treatment of sexually transmitted diseases (McCartan & Crouch, 1998). The Shambala use it to treat fits in children, as well as to treat tension, stress and mental illness (VanWyk & Gericke, 2000; Watt & Breyer-Brandwijk, 1962; Pedersen et al., 2008). In other parts of South Africa, mondia is used to treat stomachaches (McGaw, Jager, & van Staden, 2000).

In Ghana in West Africa, anecdotal evidence suggests that aqueous and ethanolic extracts of mondia root are used for the management of erectile dysfunction (Ofosuhene, 2005). From Guinea to Congo, mondia is reportedly used as an aphrodisiac (Adjanohoum et al., 1996). All across African countries in which mondia is used medicinally, the most popularly cited use for this plant is as an aphrodisiac to enhance sexual function and/or improve libido.

THE PHYTOCHEMISTRY OF MONDIA WHITEI

Although *Mondia* has been used as a medicinal plant for many generations in many countries across Africa, there is a dearth of information regarding the phytochemistry and pharmacology of this plant. A PubMed search conducted on May 1, 2012, using the terms *Mondia whitei* or *Mondia whytei* yielded only ten publications. The earliest publication was by Kubo and Kinst-Hori, who isolated and identified a 2-hydroxy-4-methoxybenzaldehyde as the principal tyrosinase inhibitor from the root of *Mondia whitei* (Kubo & Kinst-Hori, 1999). The authors also detected but did not elucidate the structures of several alkaloids. Subsequently, Koorbanally isolated and identified the previously described 2-hydroxy-4-methoxybenzaldehyde and, for the first time, reported the presence of isovanillin (3-hydroxy-4-methoxybenzaldedyde) in the methylene chloride extract of *Mondia whitei* roots (Koorbanally, Mulholland, & Crouch, 2000). Mukonyi and Ndiege later isolated and described the same compounds and also investigated the taste-modifying property of mondia roots. These researchers demonstrated that the taste-modifying property that changes taste buds so that drinking water tastes sweet or sugary was due to the presence of 2-hydroxy-4-methoxybenzaldehyde (Mukonyi & Ndiege, 2001). The authors also hypothesized that the presence of isovanillin and

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other benzylaldehydes compounds were responsible for the spicy vanilla-like flavor of mondia root.

In 2005, Patnam et al. reported an unusual chlorinated coumarinolignan, 5-chloropropacin, along with several of the other previously known benzaldehyde derivatives (Patnam, Kadali, Koumaglo, & Roy, 2005). Watcho et al. studied the phytochemistry of the hexane and methanolic fractions that were obtained from the crude extracts of the mondia root prepared by extraction using a mixture of chloroform and methanol in a 1:1 ratio (Watcho et al., 2007b). In the crude extracts, the authors detected steroids and triterpenes (mixtures of amyrine α- and ß-acetate, lupeol, ß-sitosterol, and ß-sitosterol glucoside). In the hexane fraction obtained from the crude extract, these researchers found aromatic compounds [2-hydroxy-4 methoxybenzaldehyde, 3-hydroxy-4-methoxy-benzaldehyde (vanillin), and 4-hydroxy-3-methoxy-benzaldehyde], while the methanol fraction obtained from the crude extract yielded sugars (glucose) and polyholosides [α-D-glucopyranosyl (6-1)-ß-D-glucopyranose and 1-methoxy-ß-D-glucopyranosyl (6-1)-ß-D-glucopyranose]. Msonthi et al. also reported a phenolic glycoside with the sugar 2-O- ß -D-glucopyranolsyl-(1-6)-O- ß –D- xylopyranoside (Msonthi, 1991; Msonthi et al., 1989). Taken together, these articles show that the mondia root is rich in sterols and benzyladehyde derivatives and also contains several alkaloids and glycosides.

In 2010, Neergfaard et al. reported the presence of a monoterpene lactone (−)-loliolide from the leaves of mondia. The authors employed a bioassay-guided fractionation procedure using the serotonin transporter binding assay with [^{3}H]-citalopram as the ligand to isolate the compound (Neergaard et al., 2010). The authors suggested that this lactone was responsible for the in vitro serotonin transporter affinity exhibited by mondia extracts, as reported by Nielsen et al. (Nielsen et al., 2004) and reviewed in this study under pharmacological activities. This finding is interesting, given that the material analyzed was the aerial portion of mondia, while the root is the most popularly used part of the plant.

The following section examines the data on the pharmacological properties of mondia available in the public domain.

THE PHARMACOLOGY OF MONDIA WHITEI EXTRACTS

Potential Aphrodisiac Properties

The biological activity of mondia has recently gained considerable attention and interest. Watcho et al. have performed extensive research on mondia, investigating the purported aphrodisiac/fertility modulating properties. In earlier studies, Watcho et al. reported a reversible antispermatogenic activity of the aqueous root extracts when administered to male rats for 55 days (Watcho et al., 2001). In that study, mature male rats were divided into groups 1 and 2, and each group was further subdivided into two subgroups, thus group 1 and 2 each had an experimental and a control group. All experimental animals (group 1 and 2) were given 400 mg/kg of aqueous mondia root extract, while the control animals received an equivalent amount of distilled water. All of the rats were treated for 55 days. The rats in group 1 were killed after day 55, while those in group 2 were allowed to

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live for an additional 55 days without treatment (recovery period) before sacrifice. Prior to sacrifice, four males from each treatment group were mated with females of the same species to test fertility. A complete necropsy was carried out on the sacrificed animals, and the following parameters were determined: total proteins in the testes and epididymides and testosterone and estradiol in the testes. The total proteins and testosterone were also determined in the serum, and the sperm count was determined in the cauda of the right epididymides. The results showed that after 55 days of treatment with mondia extracts, the wet weight of the seminal vesicle increased, but the weights of testes, epididymides, and ventral prostate were unchanged. Whereas a significant increase in the protein and cholesterol levels was noted in the testes and epididymides, the testosterone and 17β-estradiol levels remained unchanged during and after the study period. Although this study appears to have conflicting results in that increased testicular protein content was not accompanied by increased testosterone levels, the overall activity suggests that mondia possesses androgenic properties, due to the observed increased in reproductive organs weight, which is typically associated with androgenic activity.

In a follow-up study, the authors examined the effects of aqueous extracts of the mondia root on testosterone production and fertility in male rats (Watcho et al., 2004). In the acute toxicity experiments, four groups of rats were given a single dose of 400 mg/kg of extract. The animals were observed hourly for a period of up to 6 hr and compared to a control group that was administered vehicle (water). Animals in the experimental groups were sacrificed after 2, 4, and 6 hr, while the controls were sacrificed after 6 hr. In the chronic toxicity study, the extracts were administered at a dose of 400 mg/kg daily to three groups of rats for 2, 4, or 8 days. Animals were sacrificed at the end of the administration period and the following parameters measured: epididymal sperm density, serum testosterone, testicular testosterone, and 17β-estradiol. The serum, testicular and epidydimal protein contents were also determined. The results showed that in the acute treatment groups, the serum and testicular concentrations of testosterone remained unchanged at all time points. In the rats treated for 8 days, a significant increase was observed in the testicular weight, serum and testicular testosterone, testicular protein content, and the sperm density ($p < .05$–$.01$). The other parameters measured, including accessory gland weights, serum protein contents, testicular 17β-estradiol concentrations and fertility, were unchanged compared to the controls. The authors concluded that the aqueous extracts of the mondia root possess androgenic properties (Watcho et al., 2004).

In another study, the chronic administration of hexane extracts of the mondia root to rats elicited androgenic effects. Rats were divided into two groups and were orally administered the extract at a dose of either 500 or 1,000 mg/kg for 30 days, after which the animals were sacrificed. A control non-treated group was administered vehicle (water). Duplicate treatment groups of rats were administered 500 or 1,000 mg/kg for 30 days and allowed to live for an additional 30 days (recovery period) before sacrifice, during which the rats received no treatment. During the treatment period, the rats were weighed regularly and were sacrificed 24 hr after the last dose on day 31 or day 61. Blood was collected to determine the red blood cells (RBC) counts, the white blood cells (WBC) counts, hematocrit levels and total proteins. The reproductive organs were removed and weighed, and the tissues were

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assayed to determine total proteins (in the testes and epididymis) and cholesterol (in the testes). The physiological response of the vas deferens was also measured in terms of mechanical response of vas deferens to norepinephrine (NE) using isolated organ techniques.

The results showed that the administration of the mondia hexane extract did not cause adverse effects on body weight or testes weight. At 1,000 mg/kg, there was a significant increase in the relative weights of the caput epididymis ($p < .001$), ventral prostate ($p < .001$), and seminal vesicle ($p < .001$). At 500 mg/kg, growth was observed in the ventral prostate accompanied by a decrease in the relative weight of the proximal vas deferens when compared to control nontreated rats. In all of the treated animals, there was a decrease in the level of intratesticular cholesterol and an increase in serum and tissue total protein content. The changes in the hematological parameters were within the normal range for all treatment groups. In the rats that were allowed a recovery period of 30 days, no change was recorded in any of the parameters measured with the exception of a significant decrease in the relative proximal vas deferens ($p < .001$). Based on the increase in organ weights and the changes in the measured parameters, the authors concluded that the mondia hexane extract had androgenic effect, and because all of the measured parameters reverted to normal after the recovery period of 30days, the authors further concluded that the androgenic effect was reversible (Watcho et al., 2005).

In another study, Watcho et al. examined the effects of three mondia root extracts on KCl- and adrenaline-induced contractions of isolated rat vas deferens (Watcho et al., 2006). A crude mondia root extract was made by exhaustively extracting dry powdered mondia root with a mixture of methylene chloride and methanol (1:1) to obtain a black paste. A hexane fraction was obtained by soaking the crude extract in hexane, and the methanol fraction was obtained from the residue left after processing the crude extract with hexane. For the experiment, 1 g of extract was dissolved in 2 ml of 0.3% Tween 80 mixed with 8 ml of distilled water and was used in the experiments at concentrations ranging from 50–400 μg/ml. The authors observed a noncompetitive antagonism of all of the mondia extracts tested against the KCl-induced contraction of the vas deferens, and the activity was more prominent for the hexane extracts. Consequently, the authors suggested that the ability of the mondia hexane extract to relax KCl-induced sustained contractions involved both the receptor-operated and voltage-operated calcium channels. This activity was more prominent in the hexane fraction than in the other extracts tested, and therefore the authors attributed the bioactivity to the steroids, triterpenes, and aromatic benzaldehyde derivatives that constitute a major portion of the hexane fraction but were only a minor portion of the methanol fraction (Watcho et al., 2007b).

Other studies have attempted to elucidate how mondia extracts function in ameliorating erectile dysfunction (ED). ED occurs when there is an imbalance of, or defect in, the following physiological parameters: decreased nitric oxide (NO) generation, decreased cyclic guanosine monophosphate (cGMP) levels, and increased phosphodiestrase (PDE) activity. Therefore, Quasie et al. investigated the effects of ethanol extracts of the mondia root on nitric oxide synthase (NOS) as a surrogate marker for NO, cGMP, and PDE in attempt to elucidate the potential role of mondia extracts in penile erection (Quasie, Martey, Nyarko, Gbewonyo, & Okine, 2010; Corbin, Francis, & Webb, 2002). Male rabbits were administered oral doses

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of 100–400 mg /kg of a crude ethanolic extract of mondia root daily for 6 weeks and were compared to rabbits that were administered sildenafil at a dose of 50 mg/kg for 6 weeks as a positive control. The activity of NOS in cavernosal tissue and levels of nitric oxide NO and cGMP were measured, as well as NOS and PDE protein expressions. The NOS activity measurement was considered to be an indirect indicator of potential NO synthesis. The results showed that after a 6-week administration of mondia extract at 200 mg/kg, NOS activity was increased by 7%, and this increase was accompanied by increases in the levels of NO (88%) and cGMP (480%). However, there were no significant changes in these parameters in tissues from rabbits that had been treated with 100 or 400 mg/kg of mondia extract, and a slight reduction in NO and cGMP levels, and NOS activity was observed in the sildenafil-treated group (15.9%–37.5%). In the same study, the authors also examined the effects of various organic fractions that were obtained from the mondia ethanolic crude extracts on rabbit cavernosal tissue. The ethanolic extract was dissolved in water and then sequentially extracted with petroleum ether, chloroform, and ethyl acetate. The organic phases were dried in vacuo, and the residues obtained were used as test materials. Rabbit cavernosal tissues were incubated with the chloroform or petroleum ether fractions or the crude ethanolic extract at 0.01 or 0.10 mg/g of tissue. The results showed that the preincubation of cavernosal tissue in vitro with the crude extract or the chloroform fraction at 0.01 mg/g of tissue resulted in a significant increase ($p < .001$) in NOS activity (26%–132%), as well as an increase in the levels of NO (25%) and cGMP (50%–400%). However, these increases were not observed at the higher concentration tested (0.10 mg/g) or in tissues that were treated with the petroleum ether fraction (the authors did not report the results obtained with the ethyl acetate fraction). The authors posited that mondia extracts might influence erectile function through the activation/stimulation of NOS with corresponding increases in tissue NO and cGMP levels. The authors further speculated that the constituents present in the chloroform fraction were responsible for the biological activity. The authors suggested that an oral dose of 200 mg/kg of mondia extracts in rabbits was optimum to improve and sustain an erection via the activation/stimulation of NOS activity, resulting in the elevation of NO levels and cGMP levels, which is known to relax smooth muscle and mediate erectile function. The authors further suggested that the dose of 200 mg/kg was the threshold and that a higher or lower dose would cause an opposite effect, thereby abolishing the aphrodisiac effect. The results of this study corroborated an earlier study by Ofosuhene, which showed that mondia extracts increased cGMP (Ofosuhene, 2005).

In a separate study, Watcho et al. further demonstrated that mondia extract reduced the α-adrenergic-stimulated contraction of guinea pig corpus cavernosum tissue, resulting in muscle relaxation, which is critical for maintaining penile erection. This activity was not abolished by the activity of a nonspecific NOS inhibitor, indicating that it was independent of NOS activity (Watcho et al., 2007a). These findings were in contrast to an in vivo study showing that the crude aqueous extracts of mondia root administered at 200 mg/kg significantly increased NO and slightly increased NOS activity (Quasie et al., 2010). The differences were attributed to species differences.

To understand the action of mondia root extract as an aphrodisiac, Watcho et al. investigated the effect of aqueous and hexane extracts on the copulatory activity of

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inexperienced male rats (Watcho et al., 2007b). Male rats were orally administered 100 mg/kg or 500 mg/kg of either the aqueous or the hexane extracts of mondia root or 0.3% Tween 80 (vehicle) at 10 ml/kg as a control for 14 days. The sexual behavior of the treated rats was monitored at baseline on day 0 and during treatment at days 1, 7, and 14. The animals were allowed 14 additional days without treatment and were subsequently re-evaluated. Several fertility parameters, namely, index libido, quantal pregnancy, and a fertility index, were evaluated on day 13 of treatment by pairing rats overnight with two proestrus females. The results showed a significant decrease ($p < .001$) in the mount latency, signaling a reduction in the hesitation time of the sexually inexperienced males toward receptive females. These findings suggested that the aqueous and hexane extracts of the mondia root may act by inducing changes in levels of neurotransmitters, modulating the action of these neurotransmitters on their target cells or increasing androgen levels, as it is known that sexual behaviors are enhanced by elevated testosterone levels. Furthermore, other studies had previously demonstrated the androgenic activity of mondia aqueous and hexane extracts following chronic administration in rats (Watcho et al., 2004; Watcho et al., 2005). The enhanced copulatory activity was stronger in rats that were administered the hexane extract compared to rats that were administered the aqueous extract. This finding supported the researchers' earlier suggestion that the mondia root hexane extract was more potent than the aqueous extract and that the constituents of the hexane extracts were responsible for the biological activity.

Additional compelling evidence supporting the traditional use of mondia as a medication for sexual vitality was demonstrated by a study on human sperms using an in vitro method. Lampiao et al. administered an aqueous extract of mondia root to human spermatozoa in vitro and assessed the motility parameters. The aqueous mondia extract was administered at concentrations of 5 μl/ml, 10 μl/ml, 20 μl/ml, and 50 μl/ml to separate aliquots containing human spermatozoa. The samples were later incubated at 37°C in 5% CO_2 and motility was subsequently measured by means of computer-assisted semen analysis at various time points (30, 60, 90, and 120 min). The mondia root extract significantly enhanced total motility and progressive motility in a time-dependent manner with a statistically significant effect observed at 120 min. The authors suggested that the ability of the mondia extract to enhance sperm motility was most likely due to an increase in intracellular calcium and cyclic nucleotides through signaling pathways. The authors suggested that mondia extracts might be beneficial for the treatment of men affected with asthenozoospermia (Lampiao et al., 2008).

To elucidate mondia's possible mode of action as an aphrodisiac, Marty and He performed a detailed review in which they correlated the physiological pathways involved in penile erection with scientific findings that support the traditional use of mondia. The authors concluded that the available evidence strongly supports the use of mondia root as an aphrodisiac and in the management of erectile dysfunction (Martey & He, 2010).

No clinical studies designed to evaluate the safety of mondia extracts were found in the literature. However, in vivo studies that used high doses of mondia root extracts (doses of up to 1,000 mg/kg in rats for 30 days) elicited no adverse effects (Watcho et al., 2005). A study by Kuo et al. evaluated the physiological safety and

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reproductive effects of mondia extracts on Sprague Dawley male rats (Kuo et al., 2006). In this study, aqueous root extracts were administered orally at 100, 500, and 1,000 mg/kg daily for 7 days. The results showed no effects on body weight or organ weight. The authors also examined other physiological parameters in serum, including the albumin/globulin ratio (A/G ratio), BUN and creatinine, the levels of gamma-glutamyltranspeptidase, (GGT), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), cholesterol, triglyceride, total protein (TP), albumin, uric acid, potassium, sodium, chloride, and calcium. None of the measured parameters was changed in the treated animals compared to the nontreated control animals. Gross histopathological examinations showed no lesions in the testis or epididymus. The authors reported an increase in sperm count in all treatment groups; however, the progesterone levels were significantly reduced. Taken together, these data indicate that aqueous extracts of mondia root administered for 7 days caused no toxicity and no adverse effects on the reproductive parameters in male rats (Kuo et al., 2006).

According to the ethnobotany literature on mondia, men chew approximately 400 mg/kg of mondia root as an aphrodisiac (Watcho et al., 2005). In the studies reviewed in this report that reported safety data for mondia, extracts were tested at concentrations ranging from 50 –to 1,000 mg/kg. These extract concentrations, when translated to plant material, would be much higher by at least a magnitude of 10. Thus, it may be concluded that the dose of mondia traditionally used as an aphrodisiac would be reasonably expected to be safe.

Mondia whitei as a Potential Antidepressant

Depression and depression-like symptoms are some of the conditions that are treated with mondia. In a recent review, Jäger et al. examined plants used in South Africa to treat depression and the antidepressant activities of extracts from some of these plants (Stafford et al., 2008). Mondia was among 75 plant species that the authors investigated for the ability to inhibit serotonin reuptake. Using an in vitro serotonin reuptake transport protein-binding assay (SERT binding assay), an ethanolic extract of mondia root was shown to possess a high affinity for this transporter (Nielsen et al., 2004). Subsequent studies by Pederson et al. using an immortalized monkey kidney cell line COS-7 cells that express the human serotonin transporter (hSERT), the human noradrenalin transporter (hNAT), and the human dopamine transporter (hDAT) showed that the ethanolic extract upregulated the expression of these transporters, which is an indication that the mondia extract may modulate the uptake of norepinephrine, dopamine, and serotonin (Pedersen et al., 2008). Pederson et al. also studied the effects of mondia extracts on depression in animal models using the forced swim test in mice and rats and the tail suspension test in mice. The mondia extract was administered to animals by oral gavages at doses of 125, 250, and 500 mg/kg. The results showed that the mondia ethanolic extract at 250 mg/kg had a significant effect in the forced swim test in rats, thereby demonstrating its antidepressant effects.

To identify the phytochemicals responsible for the antidepressant effects of the ethanolic mondia extract, Neergaard et al. performed a bioassay guided fractionation using the serotonin transporter binding assay with [^{3}H]-citalopram as ligand. The authors isolated and identified a monoterpene lactone (−)-loliolide to which

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they attributed the serotonin transporter affinity (Neergaard et al. 2010). This study provides evidence supporting the use of mondia as an antidepressant. Because the investigators used the aerial part of the mondia plant, it is not clear whether the same results would be exhibited by mondia root extracts.

CONCLUDING REMARKS

In the course of this review, we found several reports indicating that *Mondia whitei* is extensively used as a traditional medicine in many countries in Africa for a wide range of conditions. However, the most common use is as an aphrodisiac.

The reviewed studies demonstrate that mondia root extracts exhibit reversible androgenic effects and may potentiate the NE action on the vas deferens. Mondia modulates the physiological activities involved in penile erectile dysfunction. For example, this plant causes an increase in NOS activity accompanied by a corresponding increase in NO and cGMP levels in carvemosal tissue or rabbits. These activities were more prominent for the hexane fraction, indicating that the phytochemicals in the hexane fraction were probably responsible for effects. In all studies where a hexane fraction was used, this fraction showed a stronger effect compared to either aqueous or methanolic extracts. The reviewed studies indicate that mondia root may increase libido and may also help maintain penile erections, although the mechanism is unclear. One article reported that mondia enhanced total and progressive sperm motility and thus may be employed in the treatment of asthenozoospermia. Although all of the studies reviewed used in vitro models, isolated organs or in vivo rodent models and, therefore, cannot be directly extrapolated to humans, these studies nevertheless provide scientific evidence that supports the traditional use of mondia as an aphrodisiac and as a treatment for sexual dysfunction.

The reviewed studies did not clearly elucidate mondia's mode of action as an aphrodisiac; however, the studies indicate that mondia's aphrodisiac properties may be mediated through various mechanisms. Aphrodisiacs may be classified into three types: those that increase (a) libido (increase sexual desire), (b) potency (maintain erection), and (c) sexual pleasure. Sexual desire may be elicited by increased testosterone levels (Haren et al., 2002), and it has been shown that mondia is able to increase serum testosterone concentrations, suggesting that it can also increase libido. Mondia was shown to reduce α-adrenergically stimulated contractions in guinea pig corpus cavernosum tissue, thus relaxing the muscle, a physiological action that is necessary for the induction and maintenance of penile erection (Tong et al., 1992). Thus, mondia may possess a therapeutic potential in the treatment of erectile dysfunction. Lastly, mondia has been shown to improve total and progressive sperm motility, and may thus possess potential as a treatment for men suffering from reduced sperm motility. This finding also lends credence to mondia's traditional use for the treatment of infertility.

Other studies have indicated that mondia may modulate the uptake of noradrenalin, dopamine, and serotonin, thus supporting the use of mondia as an antidepressant (Pedersen et al., 2008). It is generally accepted that erectile dysfunction is associated with depression, although the association is not clearly understood. One clinical study found that depression was highly correlated with erectile dysfunction

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(Seidman, 2002). It is thus reasonable to suggest that mondia's activity as an antidepressant could also augment its aphrodisiac properties.

For many traditional medicines in use today, studies are needed to determine the clinical safety and efficacy, and mondia is no exception. Although the results of the reviewed animal and in vitro studies lend support to its traditional use as an aphrodisiac and antidepressant, no controlled clinical studies have investigated these effects. An in vitro study showed that mondia may modulate the uptake of noradrenalin, dopamine, and serotonin. Therefore, in theory, mondia could interfere with the effectiveness of selective serotonin reuptake inhibitors (SSRIs), such as fluoxetine or citalopram. Further studies are needed to determine whether such interactions can occur in vivo or during clinical use.

Taken together, the ethnobotanical information, phytochemical data and pharmacological analyses results reviewed in this article demonstrate that the mondia root may be a potential new dietary supplement or a traditional medicine that could be used to support general and sexual wellbeing.

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